Control Session

State Space

* Representation
  - Controller Canonical
  - observer "
  - Paraller

* Analysis

* Design

$$\dot{x} = Ax + Bu$$
$$y = cx$$

→ **Controllability :-**

change in u → change in x (All states)

- B : non zero vector.
- Controllable Canonical

$$A = \begin{bmatrix} 0 & I \\ a_1 & a_2 \quad a_3 \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

→ non zero element

observability

ــ معناها اني أقدر أشوف ال (states) بتاعة ال (system).

$$y = C x$$

- → C : non zero vector.
- → C : non zero element

$$[1 \quad 0 \quad 0 \quad 0]$$

اما ال (matrix A) تكون (observer Canonical form)

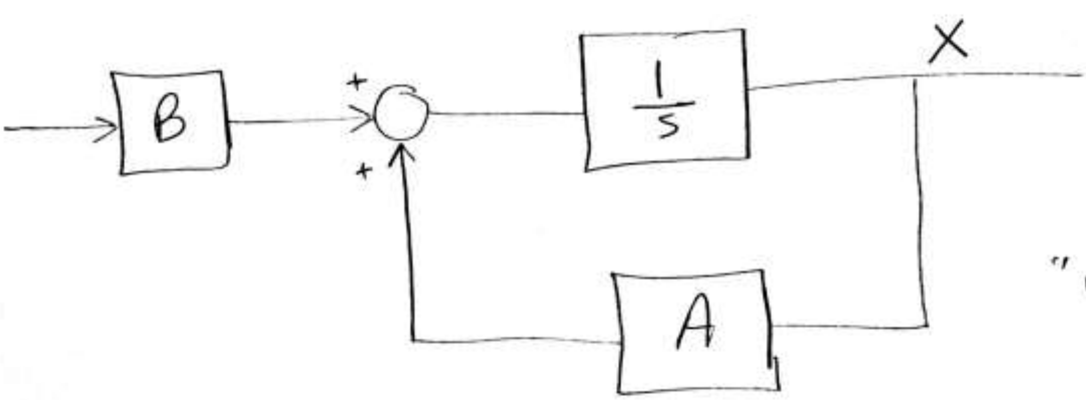
"Design"

* Desired closed loop c/c eqn

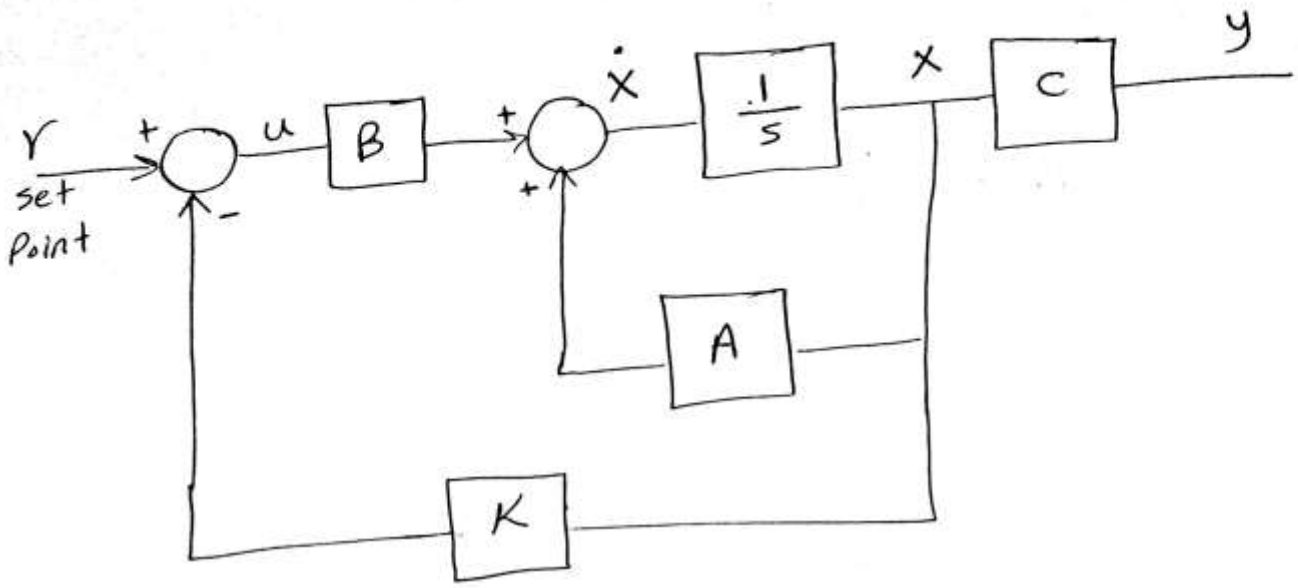
$$\alpha(s) = 0$$

In state space

$$\text{O.L.T.F} \Rightarrow |sI - A| = 0$$



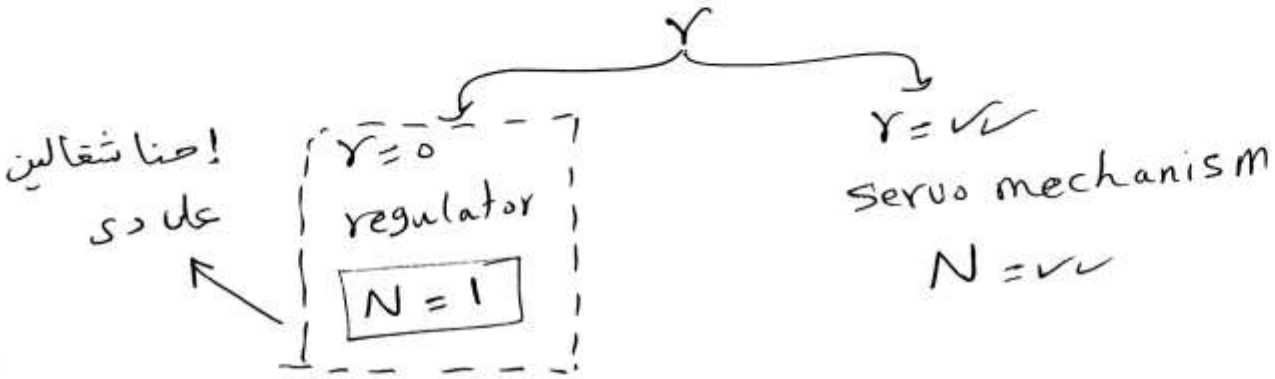
"internal feedback"



(Controller) اى ←

* بيظبط الـ (dynamics) بتاعة الـ (system).

* بيوصلنى لـ (desired gain).



C.L. system become

$$\dot{X} = AX - BKX$$

$$= (A - BK)X$$

⊗ C.L.C/C equation

$$|sI - (A-BK)| = 0$$

→ Control Target

choose K such that

$$|sI - A + BK| = \alpha_c(s)$$

[1] Coeffecient Comparison

[2] Ackarman form → $K = [0 \ 0 \ 0 \ 1] \ \mathcal{M}_c^{-1} \ \alpha_c(A)$

EX

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_1 & -a_2 & -a_3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$A-BK = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_1 & -a_2 & -a_3 \end{bmatrix} - \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ K_1 & K_2 & K_3 \end{bmatrix}$$

$$A-BK=\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_1-K_1 & -a_2-K_2 & -a_3-K_3 \end{bmatrix}$$

Given

$$\dot{X}=\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -6 & -7 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

→ Design state feedback controller such that desired C.L c/c eqn

$$\alpha_c(s) = s^3 + 12s^2 + 47s + 60$$

Sol

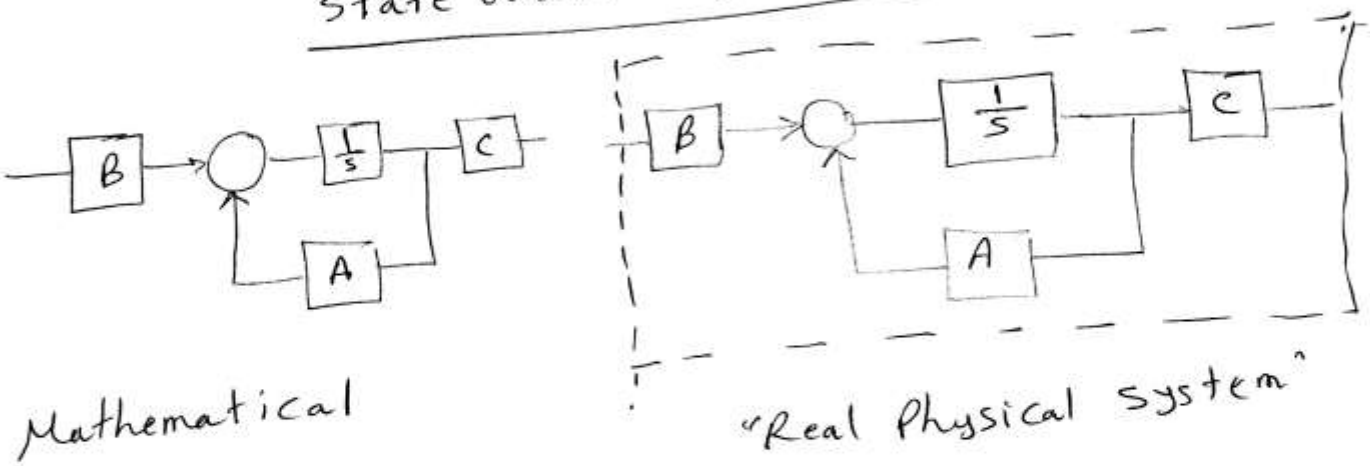
$$|sI-(A-BK)| = 0$$

$$= \begin{bmatrix} s & 0 & 0 \\ 0 & s & 0 \\ 0 & 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3-K_1 & -6-K_2 & -7-K_3 \end{bmatrix}$$

$$|sI-(A-BK)| = \left| \begin{bmatrix} s & -1 & 0 \\ 0 & s & -1 \\ 3+K_1 & 6+K_2 & 7+K_2 \end{bmatrix} \right|$$

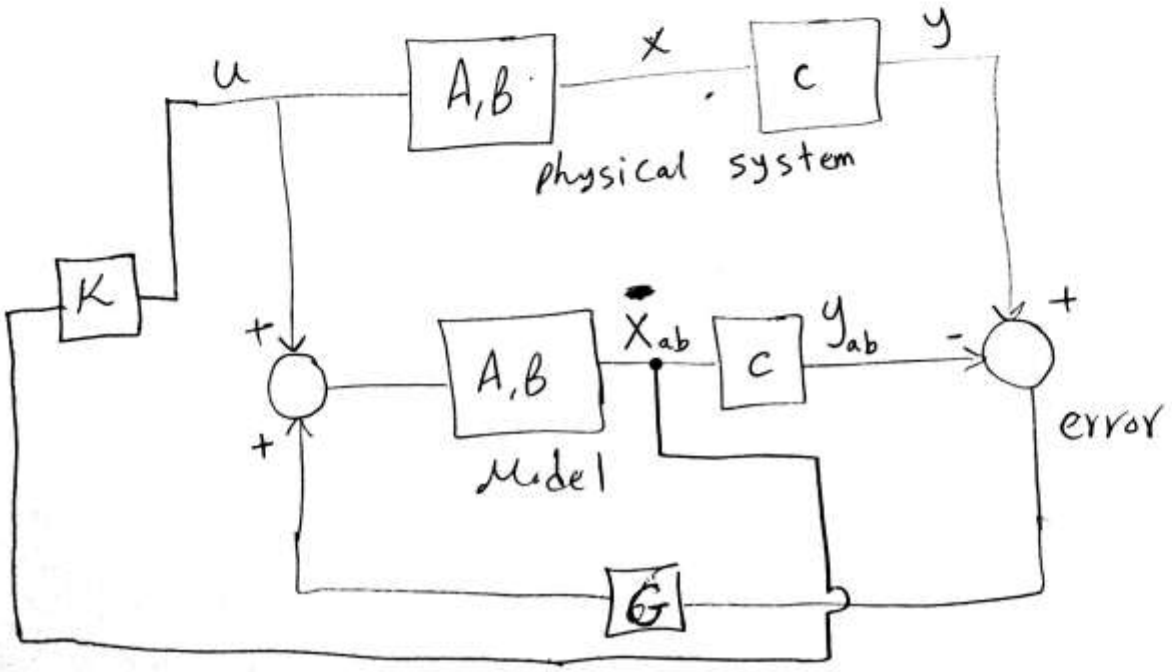
$$\boxed{s^3 + (7+K_3)s^2 + (6+K_2)s + (3+K_1) = 0}$$

state observers (estimation)



Mathematical Model

"Real Physical system"



بالنسبة لـ G ← هفضل أعطي (Actions) حتى يصل الـ (error)
جهيز . $(y - y_{ab})$.

هاخد (feedback) من الـ (model) عشان أصمم عليه الـ
(controller) بتاعي (الـ feedback الخارج من K)

← الـ (observer) لازم يكون أسرع من الـ (system)
نفسه لأن الـ (system) بيحتاج قرار معين على أساسه يقوم
بعمل (action) معين فالـ (observer) بيكون متواجد من
أجل ذلك .

$$G = \alpha_0(A)\, M_0^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

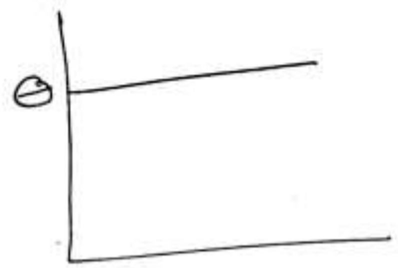
الجزء القادم معلومات عامة

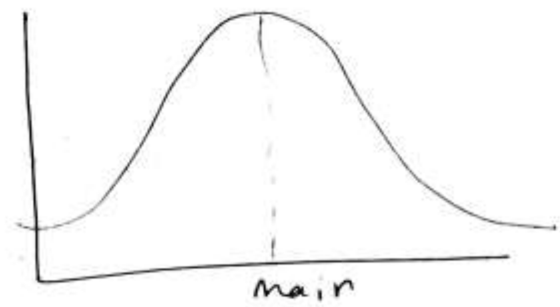
← هل لما أعمل (estimation) للـ system يكون الـ (model)
الناتج صحيح ؟! لا طبعاً هناك نسبة error .

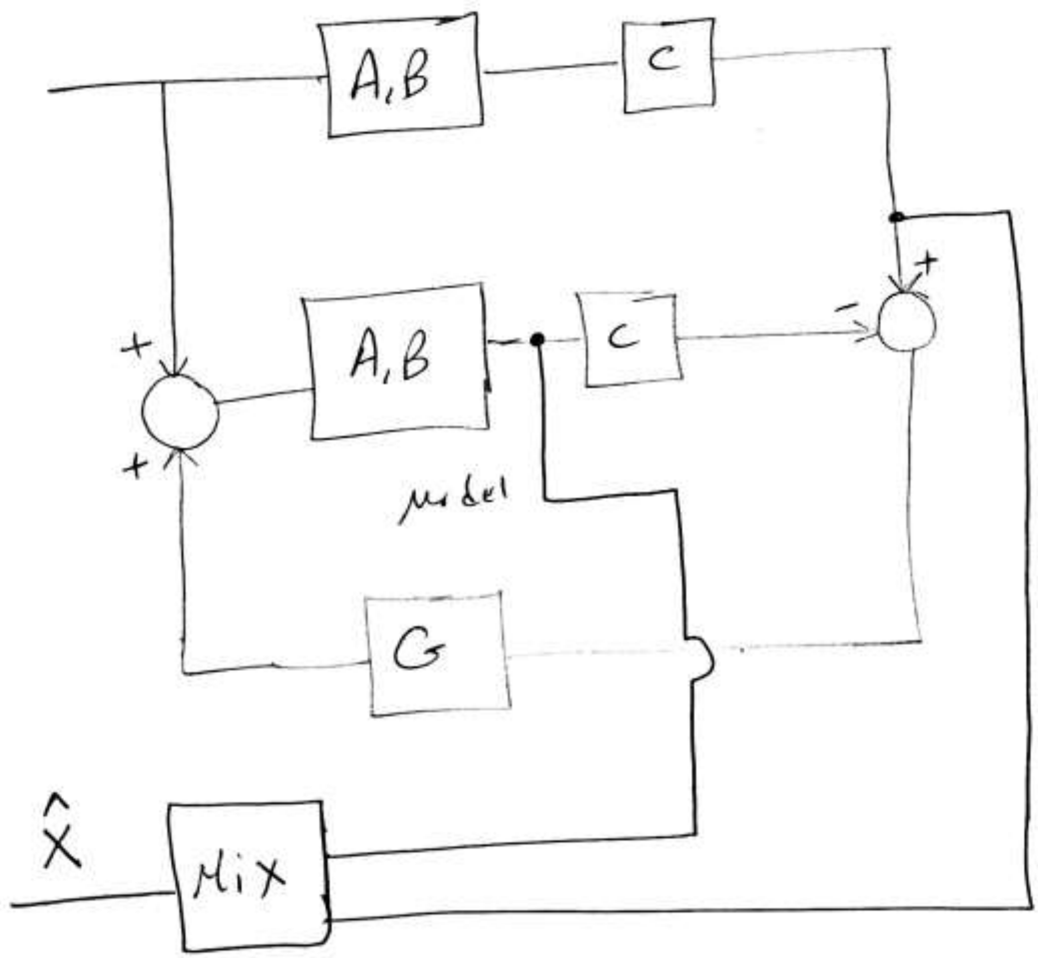
1. Model uncertainity (stochastic form)
← يصف الـ (system) على أساس الـ (uncertanity)

2. sensor noise (stochastic form)

stochastic form







← ال (model) هو (software)
يعني (digital).